

Northeastern Offshore Spotted Dolphin, *Stenella attenuata attenuata*

The estimated number of northeastern offshore spotted dolphins affected by the tuna fishery is at a magnitude and degree that will appreciably delay its recovery to OSP level.

The 2000 stock estimate is 647,218 animals (Gerrodette and Forcada 2002) which represents about 20% of the pre-fishery level (SWFSC 2002). Projections of stock size (Wade 2002) indicate that offshore spotted dolphins will take 78 years to reach the optimal sustainable population (OSP) level based on a single-slope model (38% probability) or much greater than 200 years based on a dual-slope model (61% probability).

Population dynamics and life history characteristics of spotted dolphins suggest that growth rates for severely depleted populations should be in the range of 4% per annum (Reilly and Barlow 1986). Over the last decade the northeastern offshore spotted dolphin population has either not increased or decreased (depending on the model used). The reported take in the fisheries (average of 317 per year for 1998 - 2000) is insufficient to account for the lack of growth in the population. However, there are other potential losses associated with the fisheries that could be contributing to the lack of growth in the population.

There likely is some direct take in the fisheries that is not reported. There are no reports of take from vessels smaller than Class 6 because these vessels are not authorized to set on dolphins, yet there are reports of these smaller vessels doing some fishing on dolphins.

There are also losses due to the indirect effects of fisheries. The magnitude of any of these losses is unknown, but because of the intensity of the fishery effort is high, even events that have a low probability of occurring on a per dolphin, per incident basis can result in mortalities leading to the observed no-growth pattern. The difference between the observed pattern and the predicted growth rate of 4% per annum is a little over 25,000 animals. This represents less than 0.4% of the 6.8 million spotted dolphins chased each year and less than 1.2% of the 2 million dolphins captured each year.

The most probable ways by which fisheries are causing dolphin mortalities through indirect effects are: separation between cow and calf during the chase (particularly early in the calf's life); and stress associated with chase and capture leading to enhanced susceptibility to predation. In addition, there are a number of other factors associated with the chase and capture which on a per incident basis do not make major contributions, but overall may make significant contributions to indirect effect mortalities.

These factors include: facilitated mortality associated with opportunistic predation on dolphins temporarily confined in the capture net; heat stress leading to reproductive compromise; and other physiological response factors that reach levels of concern for only a small fraction of the population.

Mesnick et al. (2002) pointed out that one of the primary evasive behaviors of dolphins to fishing activities is running. Edwards (2002) reviewed known data on cetacean propulsive capabilities as a function of body size and maturation. The maximum swimming speed a calf one year old can maintain over a period of many minutes is 2 m/s. Younger calves can only maintain lower speeds over periods of many minutes. Even for the year old calf, the speed of a typical chase, 3 m/s, means that the calf will fall behind the school at a rate of 1 m/s. Typical chases last 30 min after which time the calf could be as much as 1.8 km behind the school. This is unlikely because the chase path is more curvilinear than linear and some components of the school break away in an apparent effort to avoid capture (Heckel et al. 2000). On the other hand, the calf is unlikely to maintain its top swimming speed as the school rapidly moves away from it. Thus although the final separation of the calf from the school will likely be less than 1.8 km, it can still be a substantial distance. An abandoned calf is obviously ripe for predation and could also die of starvation should it not be able to rejoin its mother.

Although one would like to think that the female does not abandon the calf, the small amount of available evidence suggests that the female is more likely to stay with the school than to stay with the calf. Cows and calves have not been observed routinely to separate from the school during a chase. In ungulates, whose the social structure has parallels with that of pelagic dolphins, females tend to stay with the herd during a chase even if that means abandoning a dependent offspring. A surviving female will breed again whereas a female that split off from the herd to remain with a dependent offspring runs a much higher risk of dying along with the offspring. Finally, what little evidence we have from pelagic dolphins indicates that mothers and calves are separated in the chase and capture. Abella (1999) reported that in a genetic analysis of four sets, three being 100% sampled, only one of six lactating females was found to match one of five calves. Five of the six lactating females had been separated from their calves and four of the captured calves had been separated from their mothers. Often dolphins are observed waiting outside the net for release of animals within the net so some of these waiting animals could be the mothers of calves within the net. It is less likely that the calves of the mothers in the net would be among those outside the net because of the differential swimming energetics discussed above.

Archer et al. (2001) found that 82% of spotted dolphin and 74% of spinner dolphin lactating females found dead in a net were not associated with a calf. On a per set basis (based on total numbers, not genetic analyses), 0.31–0.45 spotted dolphin calves and 0.15–0.26 spinner dolphin calves were missing. This is clearly an underestimate because (1) there are no genetic data (note that in the Abella (1999) data there would

have been only one missing calf on the basis of the Archer et al. analysis because there were six lactating females and five calves even though only one pair belonged together), and (2) there is a bias in that these estimates are based only on lactating females actually caught in the net which misses all female and calves separated during the chase when the female avoids capture and death in the net.

Much effort has gone into evaluating levels of stress associated with the chase and capture of dolphins. Clearly some dolphins in the capture net experience massive shock and stress related reactions resulting in death (Cowan and Curry 2002). These animals are included in the counts of fishery mortality and will not be addressed further. A significant number of the necropsied animals showed healed lesions in the heart and its small vessels that were similar to the more severe lesions occurring in animals which die from massive shock and stress (Cowan and Curry 2002). A reasonable interpretation of these findings is that these dolphins had experienced less severe shock and stress reactions in prior chases or captures. Healing and scarring are appropriate physiological responses to injury and are to be expected over the life of an individual. However, repeated insults to myocardia tissue can lead to compromised endurance and could predispose an animal to predation. Thus there are likely deaths due to reduced cardiovascular functioning because of chase and capture induced injury and scarring. Given the intensity of the fishery and the frequency of chases and captures of individual dolphins, this could be an important contributor to indirect effects mortalities. A fuller understanding of this issue was prevented by the small number of samples provided by the fishery for this research objective.

There have been reports of predators gathering near tuna fishing operations and waiting to take advantage of the disoriented and school-disrupted dolphins being released from the net (Leatherwood et al. 1973). Predators identified as specifically feeding on dolphins being released from sets include white tipped sharks, *Triaenodon obesus*, false killer whales, *Pseudorca crassidens*, and pilot whales, *Globicephala macrorhynchus*.

Core temperature rose in only one of 48 sampled dolphins during the CHESS experiment (Pabst et al. 2002). This might indicate a problem in 2% of the population, or it might be an anomaly that occurs in only a fraction of a percent of the population. Based on the available data, we cannot determine between these levels of incidence. However, it is expected that for all physiological parameters, there will be a distribution in response with some small fraction of the population experiencing compromised physiological adaptations to levels of stress or exertion that leave the majority of the population unaffected. A pregnant dolphin that experienced elevated body temperature could suffer reproductive failure (Rommel et al. 1998).

Another example of concern with respect to animals at the extreme end of the distribution on physiological parameters was the report of the significantly elevated

serum enzymes indicative of muscle damage in some individuals involved in the CHESS experiments (St. Aubin 2002). The associated muscle damage may be great enough in some individuals to compromise their predator avoidance ability. Given that the mortalities needed to result in the observed deviation from expected population growth are relatively small compared to the size of the population and the frequency with which the population interacts with the fishery, if these animals on the tail of a physiological response distribution are negatively impacted by fisheries activities, this could contribute significantly to the indirect effects of the fishery on the stock.

Eastern Spinner Dolphin, *Stenella longirostris orientalis*

The estimated number of eastern spinner dolphins affected by the tuna fishery is at a magnitude and degree that will appreciably delay its recovery to OSP level.

The 2000 stock estimate is 427,587 animals (Gerrodette and Forcada 2002) which represents about 35% of the pre-fishery level (SWFSC 2002). Projections of stock size (Wade 2002) indicate that eastern spinner dolphins will take 64 years to reach the optimal sustainable population (OSP) level based on a single-slope model (28% probability) or will decline to extinction at some time greater than 200 years based on a dual-slope model (69% probability).

Population dynamics and life history characteristics of spinner dolphins suggest that growth rates for severely depleted populations should be in the range of 4% per annum (Reilly and Barlow 1986). Over the last decade the eastern spinner dolphin population has either not increased or decreased (depending on the model used). The reported take in the fisheries (average of 353 per year for 1998 - 2000) is insufficient to account for the lack of growth in the population. However, there are other potential losses associated with the fisheries that could be contributing to the lack of growth in the population.

The difference between the observed pattern and the predicted growth rate of 4% per annum is a little over 17,500 animals. This represents about 0.7% of the 2.5 million dolphins chased each year and about 6% of the 292,000 dolphins captured each year.

All of the points made with respect to the northeastern offshore spotted dolphins also apply to the eastern spinner dolphins. These comments will not be repeated here. I will note some spinner-specific data and some nuances in the behavior of this species that provides additional species-specific support to the conclusion that the indirect effect of the fisheries is negatively impacting the stock.

Relative to the issue of undocumented mortality of young calves through separation from their mothers during chase, aerial photographs of eastern spinner dolphins have

shown that the proportion of calves in the schools is about half of what would be expected based on the age-specific reproductive effort of the females and the age/size distributions within the schools (Cramer and Perryman 2002). All the arguments presented above regarding cow-calf separations and subsequent calf mortality resulting from the chase are consistent with the aerial photographs showing a deficit in expected numbers of calves in the schools.

Relative to the stress issue, the behavior of eastern spinner dolphins in the confines of the capture net indicate that these animals are much more stressed than northeastern offshore spotted dolphins. In fact, the differences in behavior of the two species in the capture net led the researchers in the CHES study to focus primarily on spotted dolphins. As noted in Forney et al. (2002), "spotted dolphins are also less likely to exhibit behavior that increases their risk of injury or death during sets..."

The same suite of shock and stress related cardiac histopathology noted in spotted dolphins was also seen in spinner dolphins.

Overall it is important to emphasize once again that the differences between the 4% growth rate expected for the depleted stocks of both species and the observed mortality amounts to only 0.4% of the number of spotted dolphins chased annually in the fishery and only 0.7% of the number of spinner dolphins chased annually in the fishery. The various avenues through which undocumented, indirect effects mortality could occur makes it easy to attribute the lack of growth of these stocks to the indirect fisheries effects.

Coastal Spotted Dolphin, *Stenella attenuata graffmani*

The new genetic data indicating multiple stocks of the coastal spotted dolphin and the subsequent lack of stock-specific population data and fisheries-related information precludes answering the indirect effects question for these stocks.

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